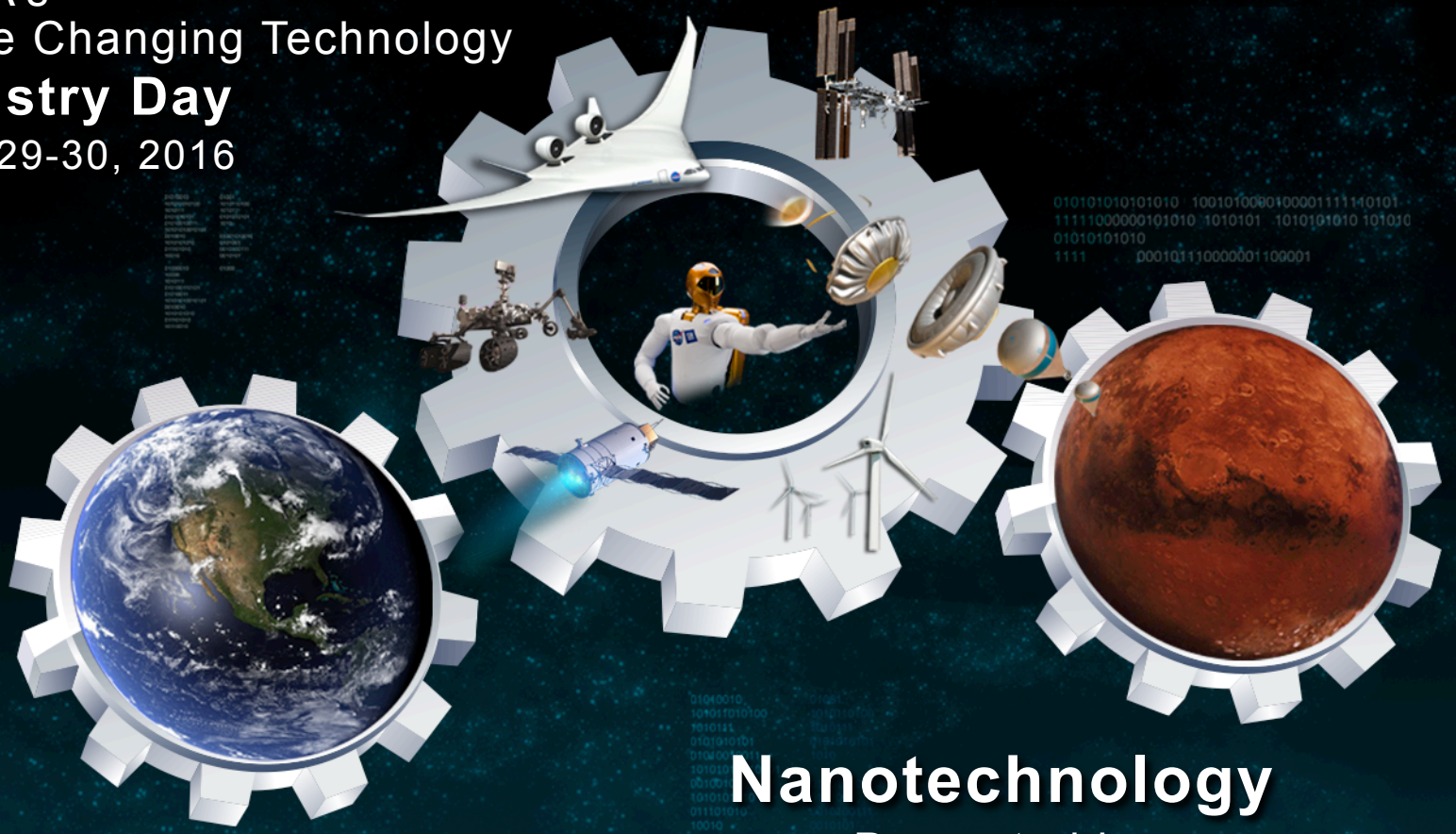
National Aeronautics and Space Administration

NASA's
Game Changing Technology
Industry Day
June 29-30, 2016



Nanotechnology

Presented by
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NASA-GRC

TECHNOLOGY DRIVES EXPLORATION

CNT Reinforced COPV

- Mature and demonstrate flight readiness of CNT reinforced composites for future NASA mission applications
  - Sounding rocket test in a multiexperiment payload
  - Integrate into cold gas thruster system as propellant storage
- The technology would provide the means for reduced COPV mass and improved damage tolerance and flight qualify CNT reinforced composites.

Cold gas thruster system on sounding rocket. One of the COPVs will be replaced with a CNT reinforced COPV for flight testing.

CNT Reinforced COPV

PROBLEM/NEED BEING ADDRESSED:

- Reduce weight and enhance the performance and damage tolerance of aerospace structures

GAME-CHANGING SOLUTION:

- Improve mechanical properties of CNTs to eventually replace CFRP – lighter and stronger
- First flight-testing of a CNT reinforced composite structural component as part of an operational flight system

UNIQUENESS:

- CNT manufacturing methods developed
- **Flight qualify CNT reinforced composites**

CNT Reinforced COPV

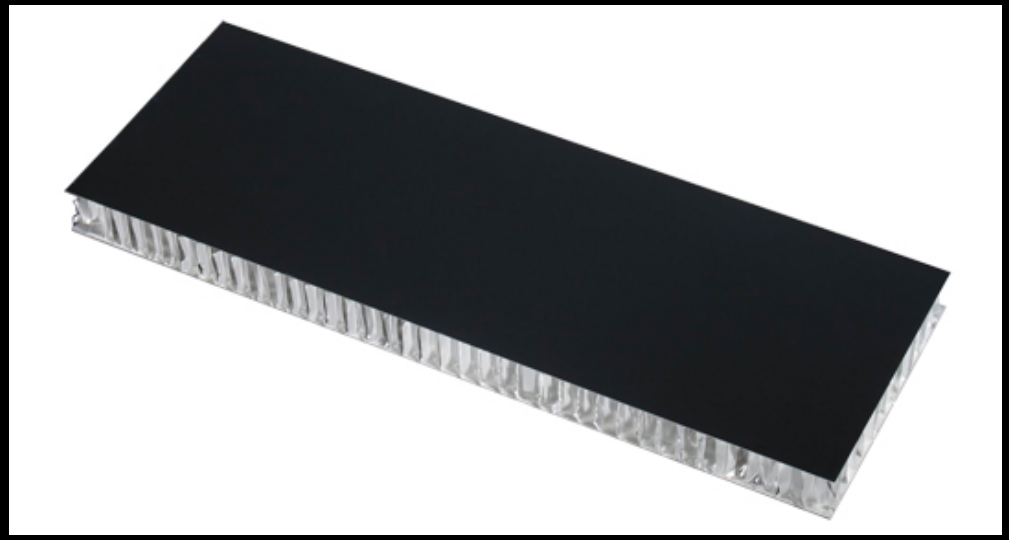
Future Benefits for Partnerships

1) Lightweight CNT reinforced composites will have a pervasive impact on both aerospace and transportation.
2) Use of these materials will
   - significantly enhance aerospace mission capabilities by enabling increased payload capacity
   - enable significant reductions in fuel consumption and emissions and decrease US petroleum consumption.

Ultralightweight Cores (ULWC) for Efficient Load Bearing Structures

- This technology aims to develop and demonstrate scalable and cost-effective manufacturing approaches to produce ultra-lightweight core materials both as flat panels and curved structures.

- Resultant structures will have half or less the areal density of conventional honeycomb cores, while retaining equivalent, or better, mechanical properties



Al honeycomb core with fiber glass facesheets

Ultralightweight Cores (ULWC) for Efficient Load Bearing Structures

PROBLEM/NEED BEING ADDRESSED:

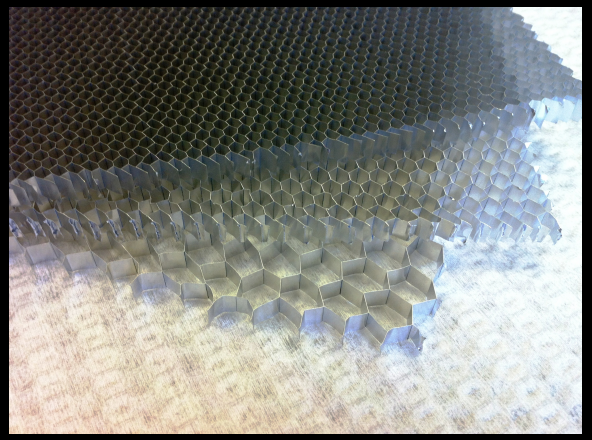
- Development of ultra-lightweight, multifunctional structures to enable significant reductions in the structural mass of future aerospace vehicles

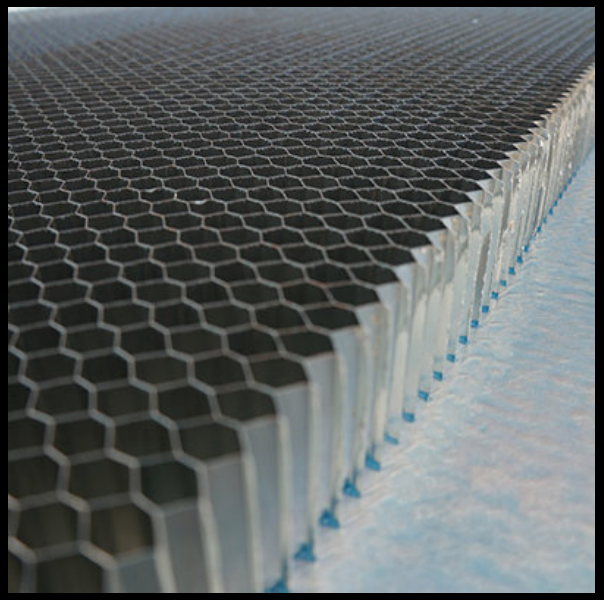
GAME-CHANGING SOLUTION:

- Substitution of ultra-lightweight sandwich structures in place of conventional honeycomb-composite sandwich structures

UNIQUENESS:

- First demonstration of ULWC materials as replacements for Al honeycomb in composite sandwich structures
- First demonstration of ULWC based sandwich structures in a load bearing structural component



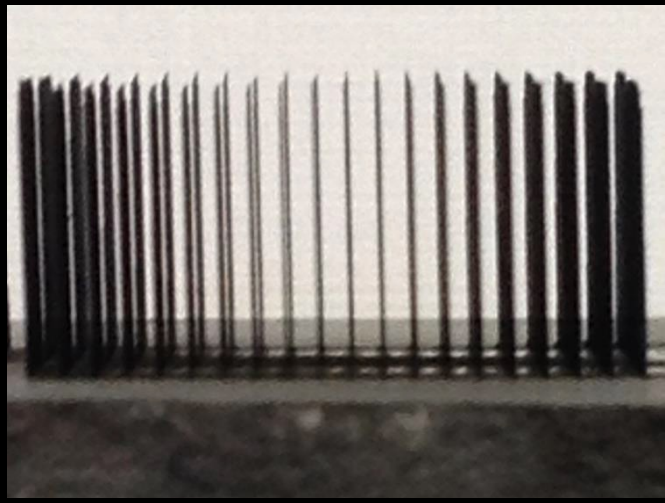


Al honeycomb cores

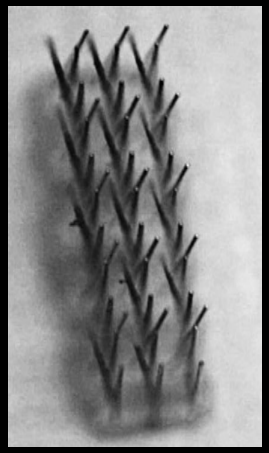
Ultralightweight Cores (ULWC) for Efficient Load Bearing Structures

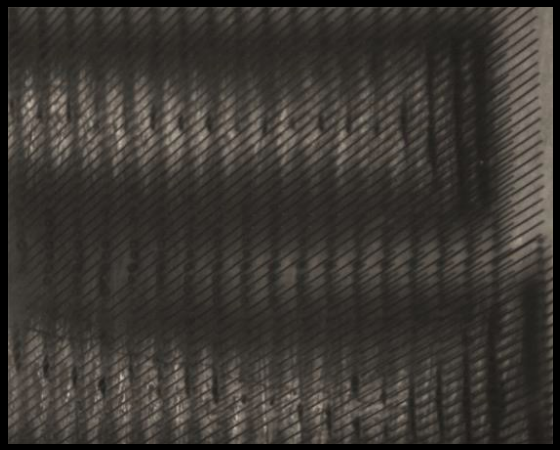
Dynetics Advanced Materials group is developing next-generation ultra-lightweight, strong materials using a variety of materials including Carbon Fiber, Boron-Carbide, Silicon Carbide as well as other binary and ternary blends.

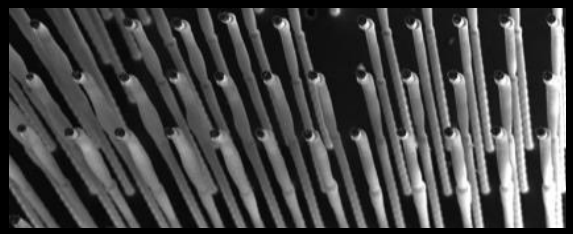
We are working with NASA to use this technology to create panel core materials with very high strength-to-mass ratios for space missions.



Example coupons demonstrate our technique with vertical and angled fiber arrays.

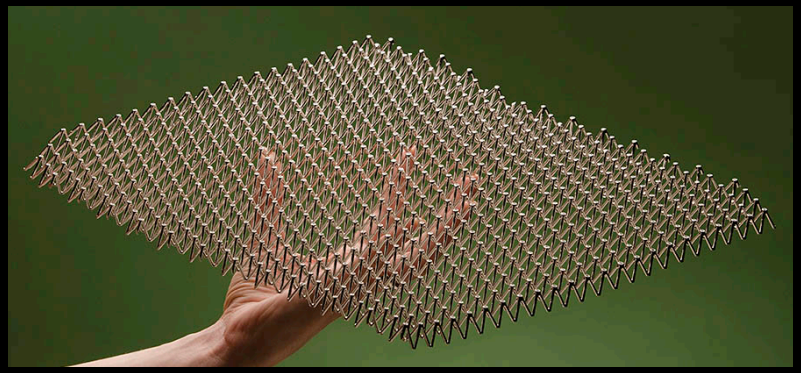






Dynetics LaserLattice™

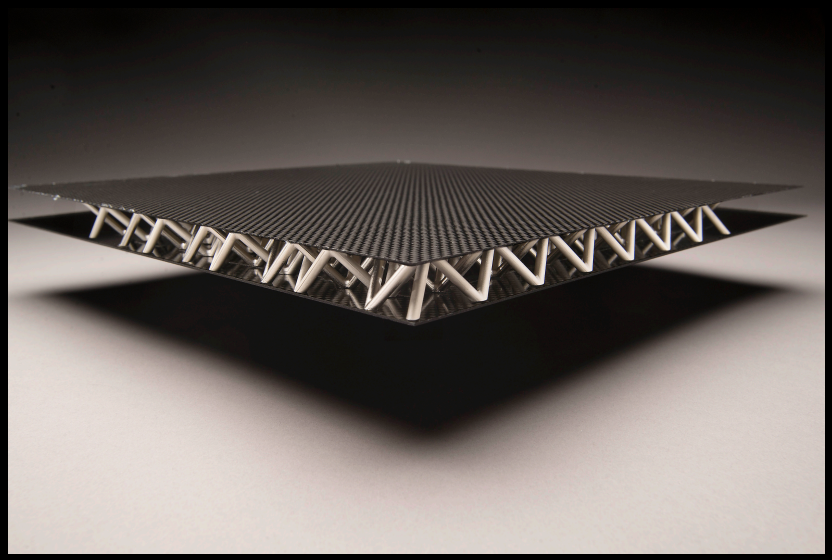
Ultralightweight Cores (ULWC) for Efficient Load Bearing Structures



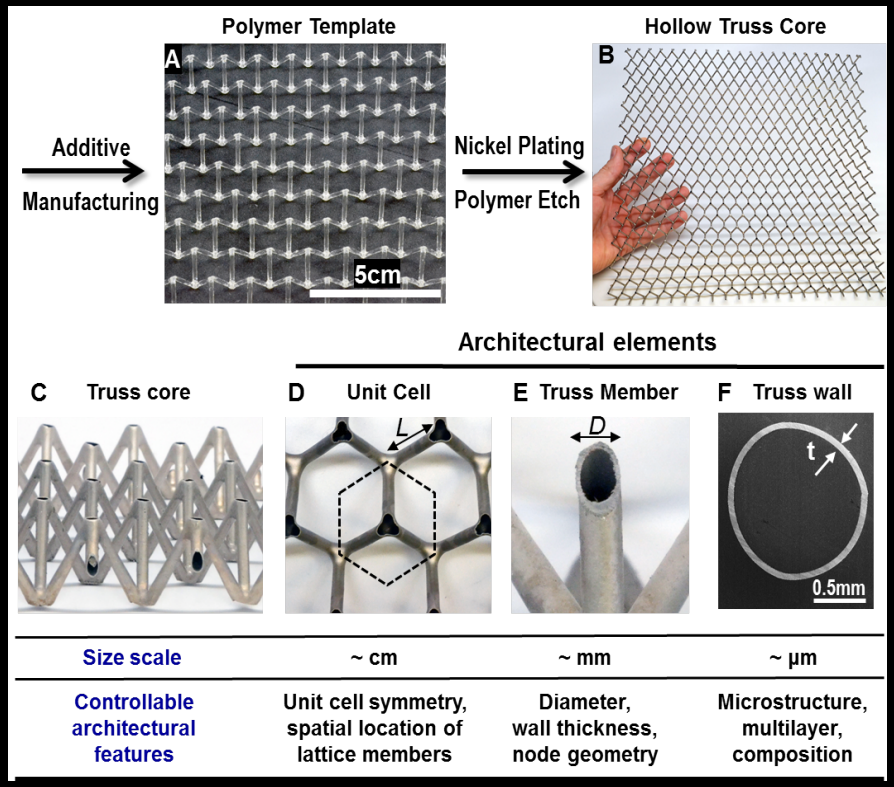
Micro-Truss Core

HRL LABORATORIES

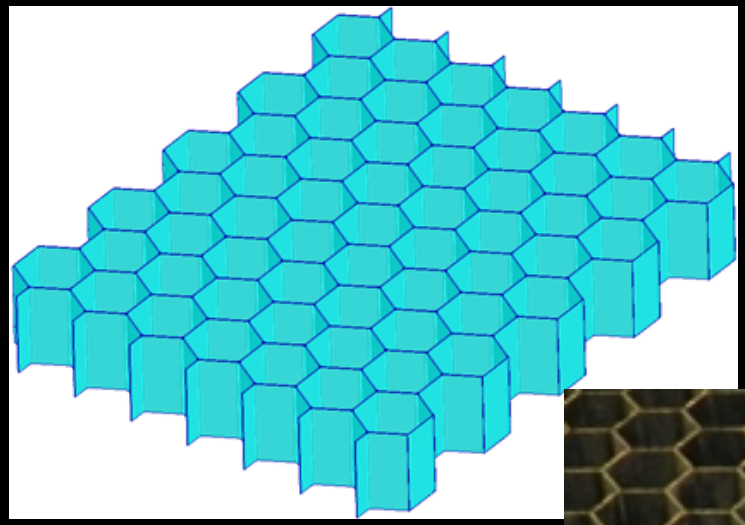
- Optimized truss architecture
- High strength nanocryst. alloys
- Scalable, low-cost fabrication



Micro-Truss Sandwich Structure



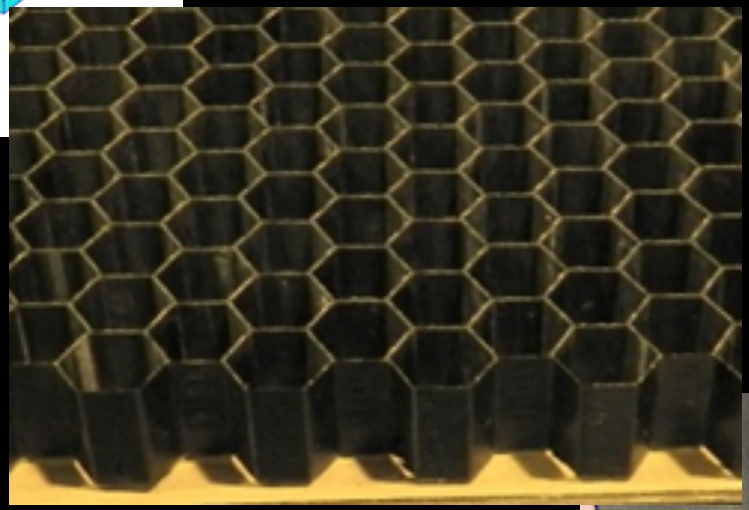
Ultralightweight Cores (ULWC) for Efficient Load Bearing Structures



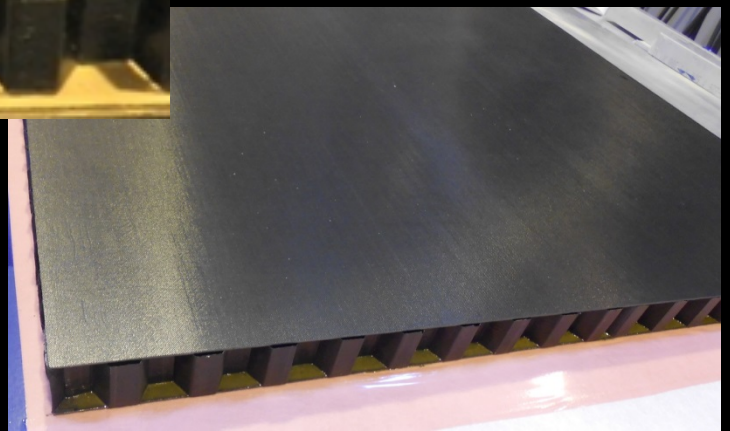
Ultra Lightweight Core design

Orbital ATK

Ultra Lightweight Core fabrication



Sandwich Panel Consolidation



Orbital ATK Developed Technology to Reduce Core Mass and Improve Core Performance

Ultralightweight Cores (ULWC) for Efficient Load Bearing Structures

Future Benefits for Partnerships

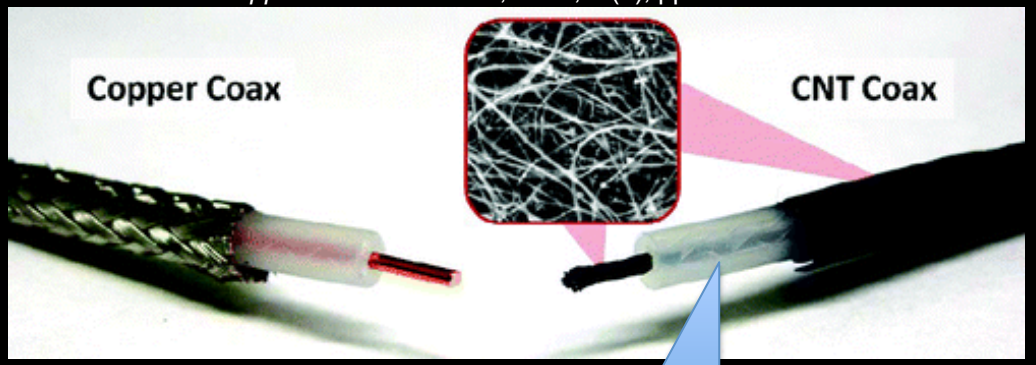
1) Demonstrate the ability to create structures scalable to the sizes needed for the SLS
2) Resulting sandwich structures hold the expectation of more than 40% mass reduction relative to conventional composite/ honeycomb sandwich structures
3) Envisioned development effort would demonstrate that materials are a cost-effective and lighter weight alternative to conventional core materials

Development and Maturation of Polyimide Aerogel as Wire Insulation

- This technology is developing methods to either coat or wrap CNT wires with polymer aerogel to replace polymer dielectric layer and integrate these concepts into a new generation of lightweight wires.

- Utilizing high conductivity CNT wires and yarns to replace copper conductors, combined with polymer aerogel electrical insulation to replace polymer dielectrics and CNT sheets to replace copper shielding can lead to up to 90% weight reduction in wiring over state of the art (copper core with polyimide jacket)

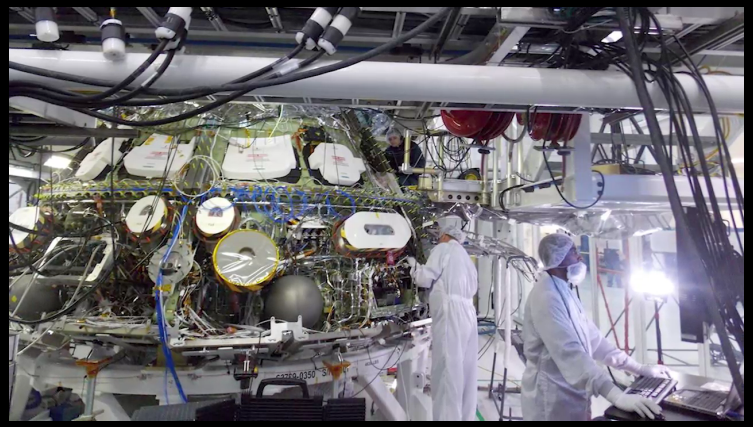
ACS Appl. Mater. Interfaces, 2012, 4 (2), pp 1103–1109



Development and Maturation of Polyimide Aerogel as Wire Insulation

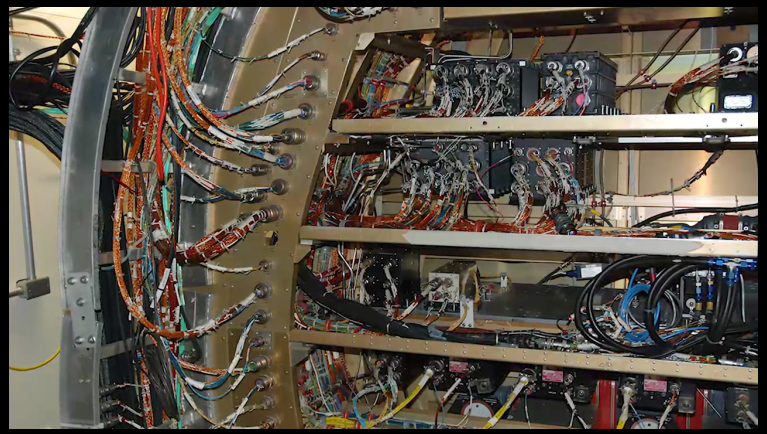
PROBLEM/NEED BEING ADDRESSED:

- Power and data cables for avionics and other parts of spacecraft add considerable weight to the vehicle



GAME-CHANGING SOLUTION

- Replace cable insulation with polyimide aerogels

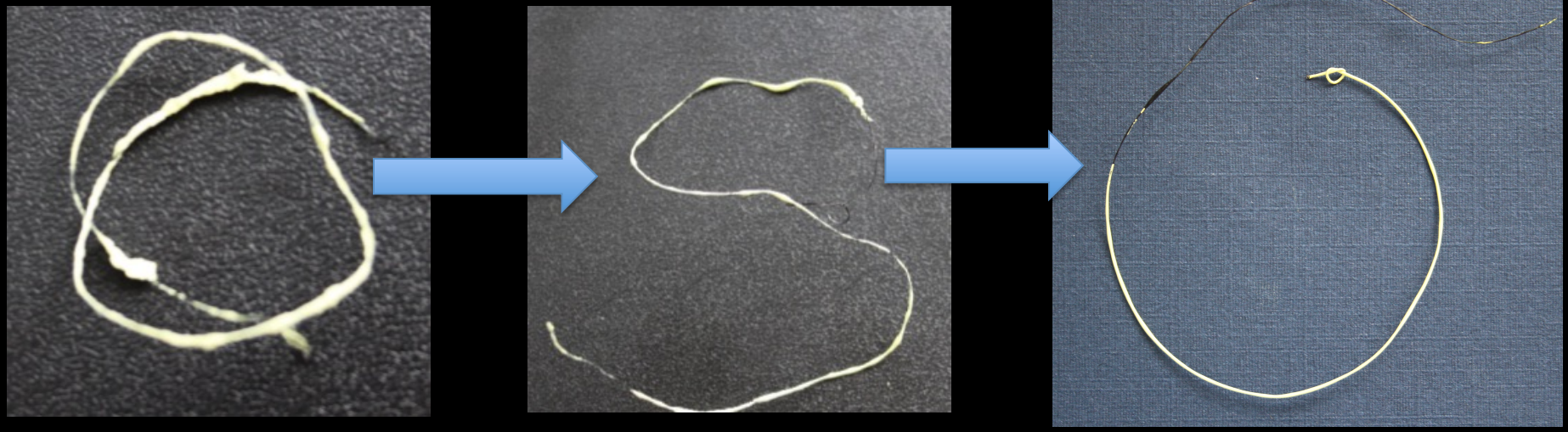


UNIQUENESS:

- Due to their low dielectric constants, using these aerogels can reduce cross-talk between fibers and the insulation layer may even be thinner than in conventional cables.

Development and Maturation of Polyimide Aerogel as Wire Insulation

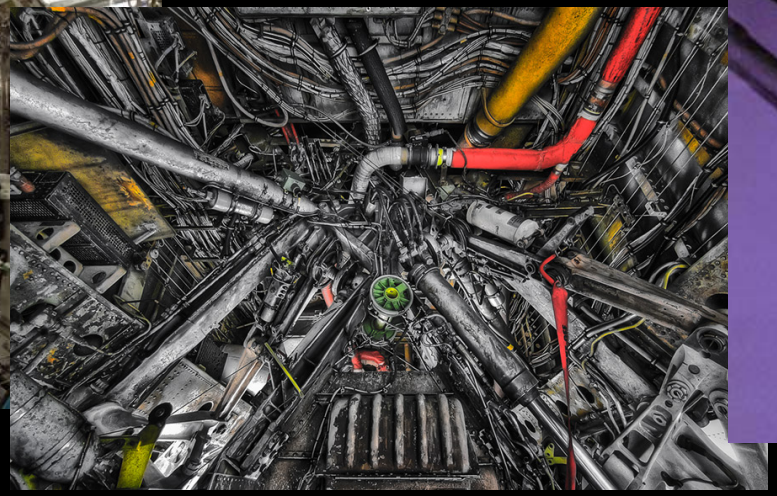
- Evenness of coating improved
- Optimization study underway to assess effect of low boiling solvent on other properties
- Began DMA tensile testing to assess failure modes of coating
- Developing lab scale coating/winding process to improve quality of coatings



Development and Maturation of Polyimide Aerogel as Wire Insulation

Future Benefits for Partnerships

1) Currently, the mass of data and power cables is increasing with the growing trend toward more autonomous vehicles, more electric architectures and the increasing use of electric propulsion
2) A reduction in wire mass will have a large return on investment for reaching targeted avionic mass reduction goals
3) Wires with aerogel insulation can provide significant mass savings for aircraft and spacecraft



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BLUESHIFT

Contact Information

For more information about this technology or to discuss potential collaboration efforts:

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CNT Reinforced COPV – Back-up